BORN-TYPE RIGID MOTION IN RELATIVITY

BY

GEORGE SALZMAN

B.S., Brooklyn College, 1949
M.S., University of Illinois, 1951

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AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS
IN THE GRADUATE COLLEGE OF THE
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In relativity theory a system of particles is represented by a family of world-lines. However, in our experience such a system has a certain shape at a given "instant" and we naturally try to pick from the four-dimensional manifold of relativity theory a three-dimensional manifold to represent the system at a given "moment." It is emphasized that there is not a unique way of choosing such three-dimensional manifolds, and therefore not a unique "natural" geometry of the system. In some cases, as e.g. the world-lines of the rotating rigid disk, distances between particles may be assigned which are not measured along any such manifolds. The idea of a natural geometry of a system of particles performing continuous motion is developed in detail, and two such geometries are given, the so-called spatial geometry and the proper time geometry.

Born-type rigid motions are defined and a set of differential equations given that characterizes such motions. The results of Herglotz and Noether[1] in classifying all Born-type rigid motions in special relativity into at least one of two classes (plane motions and group motions) is given and it is shown that each of these classes is characterized by a set of differential equations. The canonical forms for the world-lines of group motions as obtained by Herglotz in special relativity are derived and then used in examining several geometric properties of these motions.

It is shown that in special relativity it is possible to have dynamical systems, namely fluids with no heat conductivity and no ability to maintain shearing stresses, move so that the stream lines of the motion are the world-lines of a group motion. However, if the body of fluid is to be bounded, i.e. of finite spatial extent, then artificial walls must be introduced at the boundaries. If this were not done the system would fly apart and the motion would not remain rigid. This is shown both for compressible and incompressible fluids, and is not

surprising since the particles are interacting only through the pressure.

The problem in general relativity of finding a dynamical system that moves rigidly in its own space-time is formulated; boundary conditions are obtained, and it is then shown that for the rotating rigid disk, the cohesive effect of gravity is enough to give self-contained dynamical systems. One such possible system is shown.

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1. Ann. d. Phys. 31, (1909-10); G. Herglotz, p. 393; F. Noether, p. 919.

VITA

George Salzman was born on September 8, 1925 in Newark, New Jersey. After several years in the Army he returned to Brooklyn College, where he received a Bachelor of Science degree in June, 1949. Since September, 1949 he has held Teaching and Research Assistantships and Fellowships at the University of Illinois.